PERFORMANCE DEMANDS AND TRAINING INSIGHTS IN ELITE TENNIS

A GPS-BASED APPROACH

Yazar

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İçindekiler

“To my family, with gratitude”

PREFACE

Scientific studies are not merely the result of individual effort, but also the outcome of the support and contributions of many people and institutions. This book, which has been prepared from my doctoral dissertation, aims not only to serve as an academic resource but also to open new perspectives in its field. I believe that the findings obtained throughout this research will provide guidance for scholars, postgraduate students, and practitioners.

I owe deep gratitude to many individuals who made this process possible. First and foremost, I would like to express my sincere appreciation to my thesis advisor, Professor Ömer SENEL, for their patience, guidance, and invaluable support during every stage of the research.

I extend my heartfelt thanks to my family, whose patience and understanding have been a constant source of strength. Without their love and unwavering support, it would not have been possible to complete this study.

Finally, I would like to thank BİDGE Publishing House for providing the opportunity to publish this work, and I hope that this book will contribute meaningfully to both the academic community and professional practice.

Chapter 1 – The Modern Game of Tennis

The history of tennis dates back officially to 1,000 years ago. The French called it "Paume" and it was played with the hands. As the matches became more intense and it became difficult to play with the hands, players first bandaged their hands and then used wooden rackets to hit the ball faster. In 874, an English commander patented the game, which began to develop and was first registered as "Sphairstike." Later, it became known as lawn tennis. The first tennis club in history was established in 1872 in the Leamington Spa region of England. Tennis was initially played on grass courts by both men and women, but due to differences in strength and the development of courts over time, the game was divided into men's and women's categories. Today, the Wimbledon Tennis Tournament, the world's most popular tournament, began in 1877 with the men's category, and the women's category was first included in the tournament in 1884.

Tennis, which spread to many parts of the world in the 20th century, was first played in our country by the British. Club tennis began in Istanbul and continued in Izmir. Tennis began in our country in 1915 in Istanbul. The Fenerbahçe club was the first to open a tennis branch in our country, and tennis was played there until the republican era. Suat Subay, Şirinyan, and Sedat Erkoğlu, who competed internationally with the Fenerbahçe club, are remembered as the greatest names in our tennis history.

The International Tennis Federation (ITF) was founded in 1913 and the Turkish Tennis Federation in 1923. The International Tennis Federation is the largest organisation governing tennis worldwide and determining rankings. The headquarters of the

International Tennis Federation is in London. The International Tennis Federation consists of 125 members, which are national federations.

Tennis is a sport played on different surfaces such as grass, clay, and hard courts, characterised by fast shots and movements, and repetitive short runs. Additionally, it is a moderate to high-intensity sport characterised by the continuous repetition of similar movement patterns, the coordinated use of different muscle groups to achieve maximum effort, and periods of play that can be short or long in duration. Furthermore, it is a performance sport that requires high levels of fundamental motor skills such as strength, speed, endurance, flexibility, and coordination. Tennis is an individual sport that involves kinematic characteristics such as rapid changes in direction and jumping during play. Therefore, tennis players require a high level of physical fitness throughout the game. In tennis, in addition to muscle strength, explosive strength and power, speed, and agility are also essential. For this reason, training that develops anaerobic and aerobic power should be prioritised.

Additionally, the importance of having top-level motor performance characteristics in tennis has been emphasised. Studies indicate that a tennis player should have 15% strength, 25% endurance, 15% speed, 10% flexibility, and 35% coordination. Therefore, it is important to determine the current performance status of tennis players and develop appropriate training programmes to positively influence their competition performance.

1.1. Tennis Game Rules

Tennis is a sport consisting of matches played over 3 or 5 sets, depending on the nature of the tournament. Each set consists of 6 games. In tennis, to win a game, a player must score 4 points in the form of 15, 30, 40, and game. If the games are tied at 5-5, the set is extended to the 7th game. If the games are tied at 6-6, a tie-break game is played. The tie-break is the game that determines the winner in tennis. In the tie-break, points are counted individually, and the player who reaches 7 points with two different scores wins the set.

The scoring and rules are the same in doubles play. A tennis match continues without interruption from the start to the end. In three-set tournaments, the player who wins two sets wins the match, and in five-set tournaments, the player who wins three sets wins the match.

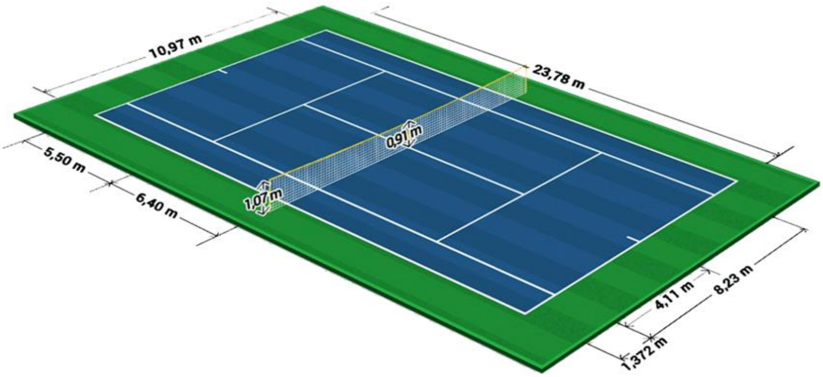

Figure 2.1. Tennis court

The tennis court is rectangular in shape, with a length of 23.78 m and a width of 10.97 m. For singles matches, the court width is 8.23 m. The court is divided into two halves by a steel wire net that runs across the top of the posts. The net must be taut, securely fastened between the posts, and constructed in such a way that the ball cannot pass through it. The centre height of the net is 0.91 m, and the side height is 1.07 m (Figure 1, ITF, 2020). For doubles matches, the net posts are positioned 0.91 m outside the centre doubles court lines on both sides. The area between the singles court lines, parallel to the net and 6.40 cm away from both sides of the net, is called the service area. The service lines on both sides of the net and the centre service line between them divide the court into two service squares. The centre service line is drawn parallel to the singles side lines and is perfectly centred. The back lines are 10 cm long and the centre service lines are 5 cm wide. All other lines on the court must be between 2.5 cm and 5 cm wide. Only the back line may be up to 10 cm wide. All measurements on the court must be taken from the outside of the lines, and the colour of the lines must be completely contrasting with the colour of the court surface (Figure 1, ITF, 2020).

1.2. The Physiology of Tennis

Tennis is an intermittent anaerobic sport consisting of a combination of low and high intensity periods, including aerobic recovery periods. Due to its biomechanical structure, which involves fast and slow movements, and the fact that matches do not have clear periods, the physiology of tennis involves very complex situations. Therefore, standardised training models are not suitable for tennis. When designing training programmes, individual differences must be taken into account, as different playing tactics, court surfaces, ball types and environmental factors all influence tennis performance. A tennis match consists of a combination of low- and high-intensity periods. During tennis matches, heart rate and VO2 Max levels increase, while these values decrease during rest periods. At the same time, tennis matches are a performance sport that is played on different surfaces for an indefinite period of time and requires high intensity. A tennis match is characterised as an intermittent exercise consisting of short periods of high intensity (4-10 seconds) followed by longer periods (60-90 seconds) of short recovery intervals (10-20 seconds). Research indicates that in a tennis match, the average point duration is 5–10 seconds, and the rest period is 10–20 seconds.

Energy requirements vary throughout a tennis match. Metabolic rate is high during points and low during rest intervals. The aerobic system helps replenish energy sources during competition. Studies generally indicate that a tennis match lasts longer than 1 hour, and in some cases can extend up to 5 hours. Physiologically, during long and fast rallies, heart rate averages around 70-80% and can rise to a maximum of 100%. Average oxygen consumption (VO2 Max) is approximately 50-60% of maximum heart rate, while during intense rallies it can reach 80% of maximum oxygen consumption. Athletes' heart rates vary depending on the intensity of the rallies played, individual technique, and game strategy. Additionally, studies have indicated that the muscle fibre characteristics of tennis players vary predominantly between fast (type II) and slow (type I) fibre types. Tennis is a sport characterised by short rest periods during strokes and longer rest periods during court changes. According to a study investigating heart rates in tennis matches, the anaerobic alactic energy system is predominantly used at 70% in tennis. The anaerobic lactic system is used at 20%, while the aerobic energy system contributes 10% to the game.

1.3. Kinematic Characteristics of Tennis

In a tennis match, athletes make an average of 1,000 different strokes and run approximately 3,000 metres. In tennis matches, the technical and tactical skills of elite athletes, as well as their ability to hit the ball harder and with more power, cause rallies to end more quickly . Research shows that tennis matches last an average of more than one hour, with some matches lasting up to five hours. On clay courts, approximately 20-30% of this time is spent with the ball in play, while on other court types, this time decreases to 10-15%. During this time, players run an average of 8-12 metres to score a point. Approximately 500 high-intensity movement profiles are observed during a match. During the match, athletes perform numerous acceleration, directional changes, and sliding movements. Athletes make an average of 2 to 5 strokes per rally. These stroke counts may vary depending on the players' technical skills, playing style, and the surface they are playing on. Approximately 80% of all strokes made by tennis players during a match occur after the players have covered approximately 2-3 metres while preparing for the stroke. The sideways movement required to make a shot during play accounts for 10% of the total, and athletes must cover a distance of approximately 2.5 to 4.5 metres to execute this shot. Therefore, tennis players must be physically well-developed to adapt to this intense pace.

Basic techniques used in tennis

In tennis, strokes are divided into two categories.

Basic strokes

- Forehand, Backhand (strokes performed on balls bouncing on the ground)

- Serve (The stroke used to start the game)

Supporting strokes

- Volley (A shot made while the ball is in the air near the net).
- Smash (A shot hit when the ball is at its highest point)
- Drop shot (short, low shot)
- Slice (a cut shot)
- Lob (High shot)

1.4. Competition Profile in Tennis

The competition profile is a modified vector magnitude designed to encompass all speed, acceleration, direction changes, and collision demands of players. It is expressed as the square root of the sum of the squares of the instantaneous acceleration changes in each of the three vectors (X: lateral, Y: anterior-posterior, and Z: vertical) divided by 100. To better address the needs of tennis, identify injury risks, and achieve high performance, it is necessary to analyse tennis-specific movement profiles and physiological and kinematic parameters. Tennis is a sport that involves various movement mechanics and has an undefined duration. Therefore, athletes must have very strong aerobic and anaerobic energy capacities.

In tennis, it is very important for athletes to achieve peak physical and mental performance in order to be successful. In particular, frequent training in children increases their physiological capacity and improves their coordination skills. Regular training at an early age helps develop tennis-specific skills. In addition to tennis training, strength training also helps develop basic motor skills. Due to the popularity of tennis worldwide and the economic opportunities it offers, players spend more than 15-20 hours per week on technical and tactical training from an early age in order to improve their tennis skills. Continuous training is necessary to improve performance in tennis. Maintaining physical fitness is important for high-level performance in tennis tournaments throughout the season. For this reason, elite tennis players and coaches devote a large part of their training plans to improving physical fitness. To be successful in tennis, technical and tactical skills and mental strength must be at a very high level. A physically inadequate athlete has very little chance of success.

1.5. Performance in Tennis

Performance is defined as the amount of work done by an individual in a unit of time, while athletic performance is defined as the effort expended to achieve success in sports competitions. Athletic performance is also defined as the level demonstrated by an individual during physical activity. Another definition describes it as the highest level of success an individual can achieve during physical activity. From the perspective of training science, it is evaluated as a goal-oriented athletic action in individual or team sports.

It is important to identify the factors that affect athletes' performance during competitions. Studies include performance classification based on skill, ability, psychological and mental characteristics, as well as physiological and kinematic suitability. Sports performance is determined by physiological and psychological characteristics. To achieve success, individual training plans based on scientific studies should be developed. If the factors affecting performance development show positive development, the expected maximum success can be achieved. The performance levels of athletes are very important for them to be successful in their sport and to maintain this success for a long time. Training tailored to the athlete's sport is necessary to improve their performance and take it to the highest level. Only in this way can an athlete gain an advantage over their competitors in their sport.

Today, the growing competition in popular sports such as tennis, the desire to reach the world rankings, or the desire to achieve the highest performance in tournaments has highlighted the importance of individual training models. In this context, there is a need to develop new methods in training science to improve athlete performance. In this context, it is observed that sport-specific training models are being developed using technologies aimed at enhancing athletic performance. Studies have shown that regularly applied appropriate training programmes increase athletes' performance levels.

Chapter 2 – Wearable Technology in Tennis

The global positioning system (GPS) is based on the synchronised emission of radio signals by 24 satellites orbiting the Earth. Using information from the satellites and certain algorithms, data on speed, position and acceleration can be obtained. These parameters enable the tracking of internal and external loads in the field of sports science. Thus, GPS technologies are used in individual and team sports to measure player positions, player speeds, and movement profiles, as well as to determine physiological and kinematic responses specific to that sport and to analyse and evaluate competition demands. GPS devices that provide both physiological and kinematic data transfer enable us to obtain information about athletes' training loads, heart rates, distances covered, acceleration, deceleration, repeated sprints, on-field positions, heat maps, running asymmetries, and power output during sprints. GPS analyses are conducted using wearable technology or heart rate monitors. Thanks to wearable technology, GPS-based player tracking systems are recognised as a reliable and valid method for monitoring athletes' activity levels in individual and team sports.

The use of GPS technology in sports science has enabled the investigation of physical profiles in many sports. Current technological developments allow for detailed analysis of factors related to competition demands. These devices have been used in some studies covering individual and team sports, and their accuracy has been found to be acceptable. It has been found to be the most reliable method in team sports that include intermittent sprints. However, Coutts and Duffield (2010) noted in their studies that the reliability of these devices may be weak in high-intensity activities.

For researchers, GPS technology is an easy and reliable system that allows them to monitor player performance in real time during competitions or training, observe and evaluate training programmes, reduce the risk of injury, and use methods tailored to competition demands to improve player performance. With the help of these devices, various physiological and kinematic parameters such as distance covered, number and duration of sprints, acceleration and deceleration, player load, and heart rate can be measured.

In recent years, wearable technologies (accelerometers, gyroscopes, magnetometers, Global Positioning System [GPS] devices, etc.) have become increasingly widespread for measuring various aspects of athletic performance. The development of GPS has enabled the collection of real-time data on human movements, making it possible to analyse sports performance in a more appropriate, efficient, and accurate manner. Global positioning system studies have shifted from evaluating state movements to assess energy consumption to evaluating human movements in sports. Global Positioning System (GPS) and micro-electro-mechanical systems (MEMS) are now widely used to measure external loads (such as direction changes, acceleration, and running distances) performed by athletes [28]. Measuring the training and competition loads imposed on athletes is an important process for promoting adaptation and managing adverse outcomes (injuries, etc.). The evaluation of the data obtained by coaches will inevitably play a significant role in player selection and on the path to high performance and success. GPS and MEMS provide insights into the planning of both the method and intensity of future field-based training. As sports technology continues to evolve, monitoring athletes' workloads, performance, and recovery has demonstrated unlimited benefits for athlete and team success. Specifically, technologies such as global positioning systems (GPS) and heart rate (HR) monitors have contributed to performance and provided opportunities for more detailed analysis of performance. Training load data obtained during training and competitions are calculated using various software, hardware, and formulas, making it easier to guide players' training content. Due to the high tempo of tennis competitions today, it is essential that training intensities are close to actual competition intensity to ensure that players can keep up with the pace. In this context, the International Tennis Federation has authorised the use of the Catapult Vector GPS device for player analysis (Appendix 2). Considering that players participate in numerous tournaments throughout the year, insufficient recovery time and the desire to be ready for upcoming tournaments can lead to sudden increases in training load, thereby increasing the risk of injury. In today's sports world, it is essential for players to maximise their athletic performance parameters before sustaining an injury. Sports scientists and athletic performance coaches monitor training loads to optimise pre-injury performance and prevent injuries. This is because players are negatively affected both psychologically and economically when they sustain injuries.

Chapter 3 – Methods

The research was conducted with the approval of the Gazi University Ethics Committee on 20 March 2022, under decision number E-77082166-302.08.01-322518. The study included 10 elite male tennis players residing in Ankara, ranked in the top 100 nationally in their age categories, with at least 8 years of licensed experience (age: 16.2±3.2 years, height: 179.4±4.7 cm, weight: 67.3±8.1 kg, sports age: 9.7±3.1 years) (Table 3.1). The players were informed about the research design, and consent was obtained from their parents, and a voluntary informed consent form was completed.

Table 3.1. Descriptive statistical information regarding the study group

Variables	**(Mean±SD)**
Age (years)	16.2±3.2
Height (cm)	179.4±4.7
Body mass (kg)	67.3± 8.1
Age of participation in sports (years)	9.7± 3.1

Mean: average, SD: standard deviation

3.1. Data Collection Tools and Techniques

To determine the physiological and kinematic characteristics of the players and their tennis movement profiles, data were collected using Vector S7 devices designed by Catapult Sports, which were placed on the mid-scapular region of each player. To determine physiological and kinematic characteristics, the following variables were identified: average heart rate (beats/min), maximum heart rate (beats/min), maximum speed (km/h), maximum acceleration ($^{m/s^2)}$, maximum deceleration (m/s^2), total running distance (m), and total match duration (min) were measured. Statistical analysis results were then compared and evaluated in detail based on winner-loser and morning-afternoon match categories.

For tennis movement profile analyses, the following variables were determined: total strokes, total strokes (1 min), match load, match load (1 min), number of serve strokes, number of forehand strokes, number of backhand strokes, volley, smash, etc., serve stroke load, forehand stroke load, backhand stroke load, volley, smash, etc. stroke load, dynamic load, stroke preparation load, running load, low- e load, percentage of time spent on all strokes, percentage of time spent on dynamically classified movements, percentage of warning time spent preparing for all strokes, percentage of time spent on movements classified as running, and percentage of time spent on movements classified as low intensity were identified, and statistical analysis results were compared and evaluated in detail according to winning-losing and morning-afternoon matches. In the study, players' height and body weight were measured.

To determine the players' performance profiles during matches, each player was made to play two simulated matches in the singles category. The matches were played under real tournament conditions, in the morning and afternoon, on an outdoor hard court. Pairings were made based on the players' country rankings. The matches were played in three sets (with a tie-break in each set) according to the rules established by the International Tennis Federation. Tennis balls approved by the International Tennis Federation were used. To better replicate real tournament conditions, each match was played against a different opponent. Players were asked about any fatigue levels and how these affected their performance during the matches while wearing wearable GPS vests, and it was determined that they did not experience any fatigue. During the measurements, experimental conditions were similar in morning and afternoon matches (average temperature$^{12–14°\mathrm{C}}$and average relative humidity 50–52%).

3.2. Vector S7 GPS device

Designed by Catapult Sports, this system, which is programmed into units placed between the players' shoulder blades and is also known as Inertial Motion Analysis (IMA), makes it possible to detect the magnitude, direction and number of acceleration, deceleration and sudden direction changes at different speeds. The units of this wearable GPS data collection technology, which includes a 3-axis accelerometer and gyroscope, measure 81 x 43.5 x 15.9 mm and weigh 54 g (Figure 3.1.). With the advancement of modern technology, this system, which is widely used especially in team sports, consists of small and lightweight GPS units placed on the backs of players. These units are individually identified for each athlete, enabling real-time analysis of performance data during training or competitions. It is the world's first GPS and athlete performance tracking and analysis system capable of operating both indoors and outdoors. IMA Direction Change, IMA Explosive Efforts, IMA Jumps, and IMA Effects parameters and the UK Tennis Federation-approved tennis movement profile protocol can only be measured in real-time using the Catapult Sports Vector S7 device, which we used in our thesis. This is the first time such a system has been used in tennis, an individual sport in our country.

Figure 3.1. Vector S7 GPS Device and Features

Physiological and kinematic parameters measured with the Vector S7 GPS device in the thesis

Average heart rate (beats/min): Indicates the average heart rate of the player during the match.

Maximum heart rate (beats per minute): Indicates the highest heart rate the player reached during the match.

Maximum speed (km/h): Indicates the highest speed achieved by the player during the match.

Maximum acceleration (m/s^2): Indicates the highest acceleration values achieved by the player during the match.

Maximum deceleration (m/s^2): Indicates the highest deceleration achieved by the player during the competition.

Total running distance (m): Indicates the total distance the player ran during the match.

Total match duration (min.): Indicates the total duration of the match.

Tennis movement profile parameters (Absolute units - mb)

Total strokes: Indicates the total number of strokes made by the player during the match duration.

Total strokes (per minute): Indicates the total number of strokes made by the player in one minute during the match.

Match load: Indicates the total match load of the player during the match.

Match load (per minute): Indicates the total match load of the player per minute during the match.

Serve count: Indicates the total number of serves made during the match.

Forehand stroke count: Indicates the total number of forehand strokes made during the match.

Backhand stroke count: Indicates the total number of backhand strokes during the match.

Number of volleys, smashes, etc.: Indicates the total number of volleys, smashes, etc., during the match.

Serve stroke load: Indicates the total number of serve strokes made by the player during the match.

Forehand stroke load: Indicates the total number of forehand strokes made by the player during the match.

Backhand stroke load: Indicates the total backhand stroke load of the player during the match.

Vole, smash, etc. stroke load: Indicates the total number of vole, smash, etc. strokes made by the player during the match.

Dynamic load: Indicates the total dynamic load of the player during the match.

Preparation load: Indicates the total preparation load of the player during the match.

Running load: Indicates the total running load of the player during the match.

Low intensity load: Indicates the player's low intensity load during the match.

Percentage of time spent on all shots: Indicates the percentage of time the player spent on all shots during the match.

Percentage of time spent on dynamically classified movements: Indicates the percentage of time spent by the player on dynamically classified movements during the match.

e of warning time spent preparing for all shots: Indicates the percentage of warning time spent by the player preparing for all shots during the match.

Percentage of time spent on movements classified as running: Indicates the percentage of time spent by the player on movements classified as running during the match.

Percentage of time spent on movements classified as low intensity: Indicates the percentage of time spent by the player on movements classified as low intensity during the match.

3.3. Height and body mass measurement

In the study, players' height was measured using a height measurer (Seca 213, Germany) with a precision of 0.1 cm, and body mass was measured using a portable scale (Seca 813, Germany) with a precision of 0.1 kg, with players barefoot and wearing shorts and a t-shirt.

The data obtained within the scope of the research were transferred to SPSS 26.0 programme for statistical analysis and evaluated. Descriptive data were presented as "arithmetic mean ± standard deviation", median, and minimum-maximum. Mann-Whitney U Test was used for comparisons between independent groups, and Wilcoxon Test was used for comparisons between dependent groups. For variables showing significant differences in the tennis movement profile analysis of winning and losing players, effect size tests were conducted using the G Power 3.1 programme (Cohen's d; 0.2 low, 0.5 medium, 0.8 high). Analysis results were evaluated at a 95% confidence interval, and "$p < 0.05$" was considered statistically significant.

Chapter 4 – Research Findings

One of the central goals of the study was to build a detailed performance profile of tennis players. Physiological data—such as average and maximum heart rate—gave us insight into how hard the body was working during matches. On average, players recorded a heart rate of about 145 beats per minute, with peaks reaching close to 180 beats per minute. These values confirm that tennis requires athletes to sustain elevated intensity over long durations, with frequent surges of maximum effort.

Kinematic data revealed how players moved. The GPS units measured maximum speed (close to 19 km/h), acceleration, deceleration, and total distance covered. Players typically ran over 4,000 meters in a single match—most of it in short sprints of just a few meters. The constant stop-start rhythm placed enormous demands on their lower body strength and energy systems. Interestingly, when comparing morning and afternoon matches, most physiological and movement variables did not show statistically significant differences. However, the afternoon matches often lasted longer and involved slightly higher intensity, possibly reflecting players' adaptation across the day.

Table 4.1. Physiological and kinematic analysis data of players during morning and afternoon matches and comparison

Variables	Morning (Mean±SD Median;Min-Max)	Afternoon (Mean±SD Med;Min-Max)	p
Average heart rate (beats/min)	144.6± 12.3 (149.5; 128–165)	143.2 ± 15.4 (144;117–167)	0.683
Maximum heart rate	178.7± .98 (177.5;164-195)	176.4± e 13.3 (179.5;150-189)	0.540
Maximum Speed (km/h)	18.7±2.5 (19.2;15.1-21.4)	± 1.6 (19.8;16-21.1)	0.359
Maximum Acceleration ($^{m/s^2}$)	3.4±0.5 (3.4; 2.6–4.3)	3.5 (3.6; 3-4.4)	0.683
Maximum deceleration ($m^{/s^2}$)	-3.7±0.5 (-3.6; -4.5; -3)	-3.8±0.7 (-3.8;-5.2--3.1)	0.61
Total running distance (m)	3962.7±824 (3695.5;3132.8-5630.8)	3933.5± 1208 (3824.4;2207.2-6129.1)	0.799
Total match duration (min.)	75.4± 14 (73;58-99)	71.8±26.9 (66;49-119)	0.541

$p > 0.05$ *Mean: average, SD: standard deviation, Med: median, Min: minimum, Max: maximum*

When comparing the physiological and kinematic analysis data of the players during morning and afternoon matches, the mean heart rate (p=0.853), maximum heart rate (p=0.853), maximum speed (p=0.912), maximum acceleration (p=0.529), maximum deceleration (p=0.853), total running distance (p=0.796), and total match duration (p=0.684) were found to have no statistically significant differences (p>0.05) (Table 4.1).

Table 4.2. Physiological and kinematic analysis data of winning and losing players during matches and comparison

Variables	**Winners (Mean±SD Median;Min-Max)**	**Loser (Mean±SD Med;Min-Max)**	**P**
Average heart rate (beats/min)	144.2± 14.7 (146.5;117-165)	145.5± 12.9 (147;128-167)	0.853
Maximum heart rate	180.1± 12.4 (183.5;150-195)	176.3±9.8 (176; 164–189)	0.393
Maximum Speed (km/h)	18.6±2 (18.7;15.1-21.1)	19.5±2.2 (20.1;15.3-21.4)	0.247
Maximum Acceleration ($^{m/s^2}$)	3.4±0.4 (3.4; 2.6–3.9)	3.6±0.5 (3.6; 3–4.4)	0.35
Maximum deceleration ($m^{/s^2}$)	-3.7±0.6 -3.5;-5.2--3	-3.8±0.6 (-3.7;-5.2--3.1)	0.353
Total running distance (m)	4069.7± 1045.6 (3825.6;2207.2-5630.8)	4035.7± 1079.2 (3694.4;3059.4-6129.1)	0.631
Total competition time (min.)	75.3±20.8 (72;49-119)	75.3±20.8 (72;49–119)	0.999

$p > 0.05$ *Mean: average, SD: standard deviation, Med: median, Min: minimum, Max: maximum*

When comparing the physiological and kinematic analysis data of winning and losing players during matches, the mean heart rate (p=0.853), maximum heart rate (p=0.393), maximum speed (p=0.247), maximum acceleration (p=0.353), maximum deceleration (p=0.353), total running distance (p=0.631), and total match duration (p=0.999) were found to have no statistically significant differences (p>0.05) (Table 4.2).

Table 4.3. Analysis and comparison of distance (m) covered by players in morning and afternoon matches at different heart rate ranges

Ranges (Mean)	Morning (Mean±SD Med;Min-Max)	Afternoon (Average±Ss Med;Min-Max)	P
60–120 HR (beats/min)	372.7±249.5 (437.2; 5.5–666.6)	± 172.2 (173.4; 7.5–451.1)	0.165
121–150 HR (beats/min)	1957.2±533.6 (2083.3;1052.7-2751)	1122.8±574.9 (1045.6;189.9-2157.7)	**0.004**
151–170 HR (beats/min)	1255±949.9 (1155.2;119.6-3033.6)	2109.5±570.7 (2029.6;1165.2-3006)	**0.029**
171–180 HR (beats/min)	191.2±210.5 (163.9; 0.1–673.3)	539.4±623.4 (444.2; 0.1–1866.9)	0.280
181–190 HR (beats/min)	22.6±37.5 (0.1; 0.1–90.6)	127.6±239.8 (0.1; 0.1–699.1)	0.739

*p<0.05 *HR: heart rate*, *Mean: mean, SD: standard deviation, Med: median, Min: minimum, Max: maximum*

When analyzing the distance (m) covered by players in morning and afternoon matches within different heart rate bands, the following results were obtained: mean 60–120 beats per minute ($p = 0.165$), the average heart rate in the 171–180 beats per minute range ($p = 0.280$), and the average 181-190 beats/min heart rate band (0.739) were found to have no statistically significant difference ($p>0.05$), while the average 121-150 beats/min heart rate band (0.004) and the average 151–170 beats per minute ($p < 0.05$) (Table 4.3).

Table 4.4. Analysis and comparison of distance covered (m) by winning and losing players in different heart rate ranges

Ranges (Mean)	Winners (Mean±SD Median;Min-Max)	Losing (Mean±SD Med;Min-Max)	P
60–120 HR (beats/min)	303.9±228.4 (279.6; 7.5–640.3)	276.3±233.4 (251.4; 5.5–666.6)	0.853
121–150 HR (beats/min)	1575.8±650.5 (1541.9;589.9-2340.7)	1504.2±758.9 (1506.5; 189.9–2751)	0.853
151–170 HR (beats per minute)	1720.8±958.5 (1642.7;353.9-3033.6)	1643.6±843.6 (1695.5;119.6-2820.3)	0.853
171–180 HR (beats per minute)	303.4±237.8 (232.2; 0.1–673.3)	427.2±659.7 (115.7; 0.1–1866.9)	0.481
181–190 HR (beats/min)	34.7±61 (0.1; 0.1–175.5)	115.5±240.2 (0.1; 0.1–699.1)	0.706

p-> 0.05 *HR: heart rate*, *Mean: average, SD: standard deviation, Median: median, Min: minimum, Max: maximum*

When comparing the distance (m) covered by winning and losing players in different heart rate bands, the mean values were as follows: 60–120 beats/min, mean 121–150 beats/min, mean 151–170 beats/min, mean 171–180 beats/min, and mean 181-190 beats per minute (bpm) heart rate band range (respectively, 0.853, 0.853, 0.853, 0.481, 0.706) showed no statistically significant difference ($p > 0.05$) (Table 4.4).

Table 4.5. Analysis and comparison of tennis movement profile data of players during morning and afternoon matches

Variables	**Morning (Mean±SD Median;Min-Max)**	**Afternoon (Mean±SD Med;Min-Max)**	**p**
Total beats (mb)	333.5±68.2 (310.5; 264–464)	350.8±126.9 (328.5; 233–578)	0.919
Total beats (1 min) (mb)	4.1±0.4 (4.0; 3.6–4.7)	4.7±0.5 (4.6;4.1-5.5)	**0.022**
Competition load (mb)	316.4±77.9 (290.5; 215–445)	300.2±146.6 (242; 113–544)	0.646
Competition load (1 min) (mb)	4.3±0.4 (4.2;3.7-5.2)	3.8±0.8 (3.8; 2.3–5.2)	0.092
Service shot count (mb)	59.2±14.6 (59;40–84)	60.4±15.5 (57;40–92)	0.959
Forehand stroke count (mb)	124.9±40.7 (111.5;88-202)	127.5±56 (116;71-234)	0.878
Backhand stroke count (mb)	108.6±16.4 (105;90-138)	119.4±48.1 (105.5;78-210)	0.798
Vole, smash, etc. shot count (mb)	40.8±7.7 (40;30–52)	43.5±12.6 (42.5;25-65)	0.678
Serve impact load (mb)	23.6± 2.5 (23.5; 20–27)	23.4± 2.3.7 (22;20-32)	0.878
Forehand stroke load (mb)	45±17.4 (41.5;26-75)	51±20.6 (49;30–90)	0.203
Backhand stroke load (mb)	30.7±8.7 (29.5; 21–51)	27±10.7 (26.5; 16–51)	0.575
Vole, smash, etc. shot load (mb)	30.1±14.5 (31.5;8-48)	30.5±18 (26;12–63)	0.799
Dynamic load (mb)	84.5±19.3 (81;59–125)	91.1±47.2 (79;42-182)	0.959
Systolic load (mb)	51.6±7.5 (54;42–63)	50.1±14.4 (47;29-70)	0.999
Running load (mb)	10.8±5.1 (10.5;4-19)	11.3±6.3 (9;4–22)	0.798
Low-density load (mb)	38.4±6.9 (38;31–53)	37.9±11.6 (38.5;16-58)	0.888
Percentage of time spent on all beats (mb)	4.2±0.6 (3.9;3.6-5.1)	4.1±0.7 (4.2; 3.2–5.1)	0.87
Percentage of time spent in dynamically classified movements (mb)	5.2±1.5 (4.8; 3.7–8.8)	4.8 (4.4; 2.3–7.6)	0.26
Percentage of warning time spent preparing for all beats (mb)	5.8±1.4 (5.6; 4–8.2)	5.7±1.1 (5.6; 4.2–7.9)	0.79
Percentage of time spent on movements classified as running (mb)	2.2±0.9 (2.2;1–3.7)	2.1±0.8 (1.9; 1.1–3.8)	0.85
Percentage of time spent on activities classified as low intensity (mb)	75.2±5.7 (76.9;65.4–81)	75.2 (75.4;70.6-78.7)	0

*p<0.05 *MB: absolute unit, Avg: average, SD: standard deviation, Med: median, Min: minimum, Max: maximum*

When comparing the tennis movement profile analysis data of players during morning and afternoon matches, it was found that only the total number of strokes per minute ($p= 0.022$) was statistically significant ($p<0.05$) among the profile variables, while total strokes (p=0.919), match load (p=0.646), match load (1 min.) (p=0.092), number of serve strokes (p=0.959), number of forehand strokes (p=0.878), number of backhand strokes (p=0.798), , smash, etc. (p=0.678), serve shot load (p=0.878), forehand shot load (p=0.203), backhand shot load (p=0.575), volley, smash, etc. stroke load (p=0.799), dynamic load (p=0.959), preparation load for strokes (p=0.999), running load (p=0.798), low-intensity load (p=0.888), percentage of time spent on all strokes (p=0.878), percentage of time spent on dynamically classified movements (p=0.262), percentage of warning time spent preparing for all strokes (p=0.799), percentage of time spent on movements classified as running (p=0.859), and percentage of time spent on movements classified as low intensity (p=0.959) were found to have no statistically significant differences (p>0.05) (Table 4.5).

Table 4.6. Analysis and comparison of winning and losing players' tennis movement profile data

Variables	**Winners (Mean±SD Median;Min-Max)**	**Loser (Mean±SD Med;Min-Max)**	**P**
Total stroke (mb)	339.7±104.6 (313.5; 233–577)	344.6±99.9 (325.5; 234–578)	0.739
Total beats (1 min) (mb)	4.6±0.6 (4.7; 3.7–5.3)	4.3±0.5 (4.2; 3.6–5.6)	0.218
Competition load (mb)	329.1±115.8 (290;182–544)	287.5±115.4 (282;113–489)	0.481
Competition load (1 min) (mb)	4.4±0.5 (4.4;3.7-5.2)	3.7±0.6 (3.8; 2.3–4.3)	**0.005**
Service shot count (mb)	52.2±11.6 (50;40-72)	67.4±13.8 (67;48-92)	**0.019**
Forehand stroke count (mb)	127.8±50.6 (114.5;71-234)	124.6±47.2 (113;72–221)	0.853
Backhand stroke count (mb)	115.2±37.3 (107;81-210)	112.8±35.3 (103.5;78-203)	0.796
Vole, smash, etc. shot count (mb)	44.5±10.5 (43.5;25-65)	39.8±10 (36.5; 30–62)	0.190
Serve shot load (mb)	24.9±3.4 (25; 20–32)	22.1 (22;20-26)	0.052
Forehand stroke load (mb)	55.1±16.1 (54;32-90)	40.9±19.4 (32.5;26-79)	**0.035**
Backhand stroke load (mb)	29.2±9.4 (28;17–51)	28.5±10.4 (28.5;16-51)	0.912
Vole, smash, etc. stroke load (mb)	32.2±17.1 (27.5;12–63)	28.4±15.4 (30;8-52)	0.684
Dynamic load (mb)	102.3±31.4 (92;78–182)	73.3±34.2 (66;42-164)	**0.002***
Preload (mb)	49.7±11.6 (47;29–70)	52±11.2 (54;29–68)	0.631
Running load (mb)	13.3±4.7 (13.5;8-22)	20)	**0.043**
Low-density load (mb)	39.3± .8 (38.5;29-58)	3)	0.631
Percentage of time spent on all beats (mb)	4.2±0.5 (4.2;3.5-5.1)	–5.1)	0.48
Percentage of time spent in dynamically classified movements (mb)	5.7±1.5 (5.7; 3.8–8.8)	.2)	**0.02**
Percentage of warning time spent preparing for all beats (mb)	4.9±0.6 (4.9;4–6)	8.2)	**0.001**
Percentage of time spent on movements classified as running (mb)	2.3±0.9 (1.2;1.2–3.8)	7)	0
Percentage of time spent on low-intensity activities (mb)	74.6±4.5 (75.5; 65.4–81)	-80.8)	0.52

$^*p<0.05$ *MB: absolute unit, Mean: average, SD: standard deviation, Median: median, Min: minimum, Max: maximum*

When comparing the tennis movement profile analysis data of winning and losing players, match load (1 min) (p=0.005), number of serve shots (p=0.019), forehand shot load (p=0.035), dynamic load (p=0.002), running load (p=0.043), percentage of time spent on dynamically classified movements (p=0.029), and percentage of warning time spent preparing for all strokes (p=0.001) were found to be statistically significant differences ($p<0.05$), the total number of strokes (p=0.739), total strokes (1 min.) (p=0.218), match load (p=0.481), forehand stroke count (p=0.853), backhand stroke count (p=0.796), volley, smash, etc. stroke count (p=0.190), serve stroke load (p=0.052), backhand stroke load (p=0.912), volley, smash, etc. stroke load (p=0.684), preparation load for strokes (p=0.631), low-intensity load (p=0.631), percentage of time spent on all strokes (p=0.481), percentage of time spent on movements classified as running (p=0.353), and percentage of time spent on movements classified as low intensity (p=0.529) were found to have no statistically significant differences between profile variables ($p>0.05$) (Table 4.6).

Table 4.7. Effect size analysis for variables with significant differences identified in the tennis movement profile analysis of winning and losing players

Variables	EB	P
Match load (1 min.) (mb)	1.8	**0**
Service shots (mb)	1.24	**0.019**
Forehand stroke load (mb)	0.85	**0.035**
Dynamic load (mb)	0.89	**0.002**
Running load (mb)	1.00	0.043*
Percentage of time spent in dynamically classified movements (mb)	1.9	**0.029**
Percentage of warning time spent preparing for all hits (mb)	1.1	**0.001**

*p < 0.05 *EB: effect size (Cohen's d 0.2 low, 0.5 medium, 0.8 high)*

When examining effect sizes for variables with significant differences in tennis movement profiles between winning and losing players, the following were identified: match load (1 min.) (EB= 1.81/high), number of serve shots (EB=1.24/high), forehand shot load (EB=0.85/high), dynamic load (p=0.89/high), running load (EB=1.00/high), percentage of time spent on dynamically classified movements (EB=1.92/high), and percentage of warning time spent preparing for all strokes (EB=1.10/high) were identified (EB>0.8).

Chapter 5 –Discussion

This study was conducted to examine the simulated match profiles of elite young male tennis players in the morning and afternoon using the Catapult GPS device Vector S7 model. Recent technological advancements in sports science have enabled the use of devices in training science that provide more reliable information about athletes' performance, thereby facilitating the development of training models tailored to the sport and the athlete. Studies reveal that GPS. It is among the most commonly used methods for analyzing competition profiles. GPS technology provides information about players' competition profiles, physiological, and kinematic parameters. Therefore, information about the instantaneous activity profile during competition is crucial for preparing appropriate individual training load management and programs. Within the scope of this study, the Catapult GPS device Vector S7 model was used to examine both the tennis movement profiles and the physiological and kinematic responses of elite tennis players in simulated matches (morning and afternoon) on the same day, and to analyze the results based on the match outcomes (winner-loser).

Martin et al. (2011) reported an average heart rate of 154 ± 12 beats/min for male tennis players during clay court matches and 141 ± 9 beats/min during hard court matches. In a study conducted by Bergeron et al. (1991) our findings showed that 10 elite male tennis players reached a heart rate of 144±13.2 beats per minute during simulated matches. In a study conducted by Ferrauti et al. (1998), the average heart rates of 12 elite male tennis players during matches were found to be 140.1±15.5 beats per minute. In a study by Davey et al. (2003) the heart rates of male tennis players during matches were found to range between 146±3 and 157±4 beats per minute during service games and between 140±4 and 148±4 beats per minute during return games. Smekal et al. conducted a study on 20 elite male athletes ranked in the top 30 nationally and found that the average heart rate during simulated tennis matches was 151 ± 19 beats per minute. When comparing the heart rates of players during offensive and defensive play, the average heart rate of defensive players was found to be 158 ± 16 beats per minute.

In contrast, the average heart rate of offensive players was 145 ± 19 beats per minute. Reid and Schneiker (2008) found in their study that the heart rate of male tennis players ranged from 160 to 182 beats per minute in four different tennis training sessions that closely resembled normal and high-level competition conditions commonly used on the court. The average heart rate of tennis players in simulated matches in our study is consistent with the results of the aforementioned studies.

In their study, Girard and Millet (2004) determined the average heart rates of elite male tennis players during competition to be 181.8 ± 11.9 and 172.8 ± 17.2 beats/min, and their maximum heart rates to be 201.1 ± 8.5 beats/min. Fernandez et al. (2009) determined the maximum heart rate of 10 elite male tennis players during a training match to be 180.3 ± 6.5 beats per minute. Baiget et al. (2014) found that male tennis players exerted 70-80% of their maximum heart rate during matches. Girard and Millet determined that the heart rates of elite male tennis players during matches ranged between 70% and 90%. Fernandez et al. (2006) found that during long rallies in matches, the maximum heart rate of elite male tennis players reached 190-200 beats per minute. Differences were observed between players serving and receiving serves during matches. König et al. (2001) found that the heart rate of the serving player was higher than that of the receiving player. In this context, the data in the literature indicate that tennis is generally classified as a long-duration moderate-intensity exercise, despite its high-intensity exercise periods. The average heart rates of elite male tennis players in the aforementioned studies were found to be higher than those of our study. The reasons for this are thought to stem from factors such as sports experience, the surface on which tennis is played, the opponent's performance, technical and tactical positions during the game (including defense, attack, and serve usage), and the time of the match.

No statistically significant difference was found in the comparison of heart rate (beats/min) and maximum heart rate between morning and afternoon matches (Table 2). When comparing winning and losing players, although no statistically significant difference was found, the maximum heart rate was higher in winning players than in losing players (Table 3). This result may be due to losing players playing at a lower tempo, while winning players play at a higher intensity during the match. In tennis matches, continuous anaerobic power may be required during strokes. This situation necessitates maintaining a high heart rate level for optimal performance. In morning tennis matches, Gallo-Salazar et al. (2015) found that the heart rate of elite young male tennis players was 157±7 beats/min, whereas in afternoon matches, it was 154±10 beats/min.

Additionally, when comparing the heart rates of winning and losing players, they found that the winners had a heart rate of 156 ± 8 beats per minute, while the losers had a heart rate of 155 ± 9 beats per minute. The maximum heart rate was 193±5 beats per minute for winners and 191±8 beats per minute for losers. The findings of Gallo-Salazar et al. (2019) are similar to those of our study, showing no significant differences in heart rate values between morning and afternoon matches or between winning and losing players.

When accelerations were examined in external load tracking during matches, parameters that were not reflected in internal loads during acceleration and deceleration, but could only be observed with technological tracking systems and determined with objective data, were obtained. Including accelerations in training load tracking calculations revealed significant differences and provided more reliable results for match demands. Upon examining the kinematic findings of our study, although there is no statistically significant difference, it was observed that players covered more distance in competitions held in the afternoon than in those held in the morning (Table 2). When comparing winning and losing players, the total running distance covered was found to be higher in winning players than in losing players (Table 3). When the variables of maximum speed, maximum acceleration, and maximum deceleration were examined, although there was no statistically significant difference, it was observed that the maximum speed was higher in afternoon matches and in losing players (Table 2, Table 3). The reason for the lower total running distance covered during matches by losing players and the higher maximum speed in afternoon matches, particularly among losing players, is thought to be related to the players' fatigue levels.

The maximum heart rate during the competition was measured in the morning and afternoon sessions for both winning and losing players. The heart rate range was found to be 121–150 beats per minute (winning players: 1575.8 ± 650.5; losing players: 1720.8 ± 958.5) and 151–170 beats per minute (losing players: 1504.2 ± 758.9; winning players: 1643.6 ± 843.6) during the competition. (losers: 1504.2 ± 758.9 m, 1643.6 ± 843.6 m) heart rate band range. These data indicate that tennis is both an anaerobic power-demanding and an aerobic sport. Hoppe et al. (2014) in their study on elite young male tennis players, found that the total match duration was 81.2 ± 14.6 min, the total running distance was 3362 ± 869 m, the maximum speed was 4.4 ± 0.8 m·s-1, and the average heart rate was 159 ± 12 beats/min.

In our study, when examining the results of the kinematic measurements of winning and losing players, although there were no statistically significant differences, it was observed that only the maximum speed was significantly higher in losers compared to winners. This finding is consistent with previous studies analyzing the movement and stroke patterns of elite young male tennis players, which reported that losers achieved higher maximum speeds than winners. This result may be related to fatigue in the losing players. Additionally, the increase in maximum speed observed in losers may be related to the increased pressure they face when performing backhand strokes (i.e., time constraints). However, since we do not know the stroke characteristics (winners, errors, etc.) or directions (backhand, forehand, etc.), this is merely a hypothesis. Therefore, further research is needed to establish a relationship between running activity and stroke characteristics and directions in elite tennis players.

Lopez-Samanes et al. (2016) found that, although elite male tennis players could run longer distances at both low and high speeds during afternoon matches, their running activity per minute of play was similar. Based on previous studies showing that elite male tennis players perform better in afternoon matches compared to morning matches et. This result could have a significant impact on the match outcome. Reid and Duffield (2014) determined in their studies that the 2012 Australian Open men's singles final lasted 5 hours and 53 minutes, and that the players covered a distance of more than 6 km (Novak Djokovic: 6625 m, Rafael Nadal: 6219 m). Reid and Schneiker (2008) in their study determined the total running distance covered by elite male tennis players in four different tennis training sessions under conditions similar to those of a match to be between 3,460 and 1,136 meters. These values may vary depending on the level of play and court conditions. Total running distance is the most common measure of internal and external load obtained using wearable technology. This measurement is performed using GPS data and calculated by integrating positional differentiation. Although not all manufacturers disclose the method they use, two major GPS manufacturers (Catapult Sports and GPSports) report that they use positional differentiation to calculate distance. Total running distance is reported according to speed zones, and the determination of low-speed, high-speed running, and sprint thresholds is commonly used. In the study, the ITF-approved Catapult Sports Vector S7 device was preferred to obtain more reliable data, and the results were found to be generally consistent with literature findings.

In the literature, studies have also shown that the total running distance covered in consecutive tennis matches decreases in the afternoon for elite young male tennis players. In our study, however, our findings showed that elite male tennis players covered more distance in afternoon matches than in morning matches. Afternoon matches lasted longer than morning matches, which could be due to the total match duration in both matches and individual player differences. Additionally, it may be due to longer rally durations in afternoon matches. Therefore, differences in rally duration between morning and afternoon matches may explain the significant differences in total match duration, which could be related to players' technical and tactical skills, game situations, or fatigue levels.

In our study, our findings showed that only the total number of strokes in 1 minute was statistically significant among the tennis movement profile variables during morning and afternoon matches, while the total number of strokes, match load, match load (1 min), serve shot count, forehand shot count, backhand shot count, volley, smash, etc. shot count, serve shot load, forehand shot load, backhand shot load, volley, smash, etc. shot load, dynamic load, shot preparation load, running load, low-intensity load, percentage of time spent on all shots, percentage of time spent on dynamically classified movements, percentage of warning time spent preparing for all strokes, percentage of time spent on running-classified movements, and percentage of time spent on low-intensity-classified movements were found to have no statistically significant differences (Table 4). Statistically significant differences were found between the tennis movement profiles of winning and losing players in the variables of match load (1 min), number of serves, forehand stroke load, dynamic load, running load, percentage of time spent on dynamically classified movements, and percentage of warning time spent preparing for all strokes, total number of strokes, total strokes (1 min.), match load, number of forehand strokes, number of backhand strokes, volley, smash, etc., serve stroke load, backhand stroke load, volley, smash, etc. stroke load, preparation load, low-intensity load, percentage of time spent on all strokes, percentage of time spent on movements classified as running, and percentage of time spent on movements classified as low-intensity did not differ statistically significantly (Table 5).

Chapter 6 –Conclusion and Resources

Within the scope of the analysis of the competition profiles of elite young male tennis players using a GPS device, no statistically significant difference was found between the physiological and kinematic parameter data of two simulated consecutive matches played in the morning and afternoon and between winning and losing players. Although there was no statistically significant difference between winning and losing players, the maximum heart rate was found to be higher in winning players than in losing players. This may be due to losing players playing at a lower tempo and winning players playing at a higher intensity during the match.

When the kinematic findings of our study were examined, it was determined that, although there was no statistically significant difference, players covered more distance in matches held in the afternoon than in matches held in the morning, and when winning and losing players were compared, the total running distance covered was higher in winning players than in losing players. When examining the variables of maximum speed, maximum acceleration, and maximum deceleration, although there were no statistically significant differences, it was observed that maximum speed was higher in afternoon matches and in losing players. The reason for the lower total running distance covered by losing players and the higher maximum speed in afternoon matches and among losing players is thought to be related to the players' fatigue levels.

In the analysis of tennis movement profiles, it was found that only the total number of strokes (1 min) was statistically significant between matches played in the morning and afternoon, while no statistically significant differences were found between other variables. The variables of tennis movement profiles of winning and losing players included match load (1 min), serve shot count, forehand shot load, dynamic load, running load, percentage of time spent on dynamically classified movements, and percentage of warning time spent preparing for all shots, while no statistically significant differences were found between other variables. When examining the effect sizes of the differences identified in the parameters with statistically significant differences, it was found that the effect sizes were high in all parameters.

This study revealed that the physiological, kinematic, and tennis movement profile responses of elite young tennis players differed according to the match time slot (morning and afternoon) and match outcome (winner-loser) in a simulated tournament with two tennis matches per day. These results suggest that playing a match in the morning may lead to performance decline in afternoon matches due to fatigue-related factors affecting player load management and physiological and kinematic responses.

Despite the limited number of studies in the literature investigating simulated match profile analysis in tennis using Catapult Sports GPS devices, no such study has been conducted in our country. Therefore, this study, which investigates the prevalence of simulated tennis matches among a group of elite young athletes who have achieved ranking in Turkish championships, is the first of its kind in the Turkish population and in the field of tennis, according to the current literature. This study is expected to contribute to national and international research in this field, highlight the necessity of investigating the topic at the Olympic level, and enhance the statistical power of results obtained through collaboration and data sharing with different athlete and researcher groups at the Olympic level.

The following recommendations can be made for further studies that may be conducted following this research:

- A study could be conducted using the same research model on elite female players, and the results could be compared.
- The same research model can be applied to different age categories and comparative studies can be conducted.
- The same research model can be applied on different court surfaces and the results compared.
- The same or similar research model can be applied by collecting data during official competitions.
- Studies can be conducted to determine training load by maintaining a standard simulated competition duration.
- The same research model can be applied using different GPS devices, and the results can be compared.
- The same research model can be conducted with the addition of video analysis equipment.
- The same research model can be applied by conducting more competitions, and the results can be compared.

It is believed that by using the data obtained in this way to adapt training plans to the demands of actual competitions, coaches and athletes can be guided in developing individual training load management strategies aimed at improving player performance and minimising the risk of injury.

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